Reputation Risk Contagion

Financial Risk and Network Theory
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Overview of aims and methodology

Overall aim: to measure to what extent the reputation of one organisation is affected by the reputation of other similar organisations

- **We measure reputation by data mining targeted content, followed by sentiment analysis of that content. Result: a single-number measurement of reputation on a per-day basis.**
- **Use the reputation measure to elucidate a network structure, using a Bayesian methodology. (Nothing is assumed about such a network *a priori*.)**
- **Use the *de Groot* method to measure consensus, and hence the proportion of reputation due to systemic factors.**

What is reputation?

“Reputation”

A perception of an organisation on the part of stakeholders that can affect, positively or negatively, the business relationship between the stakeholder and the organisation

“Reputation Event” - ***An occurrence or action that affects Reputation***

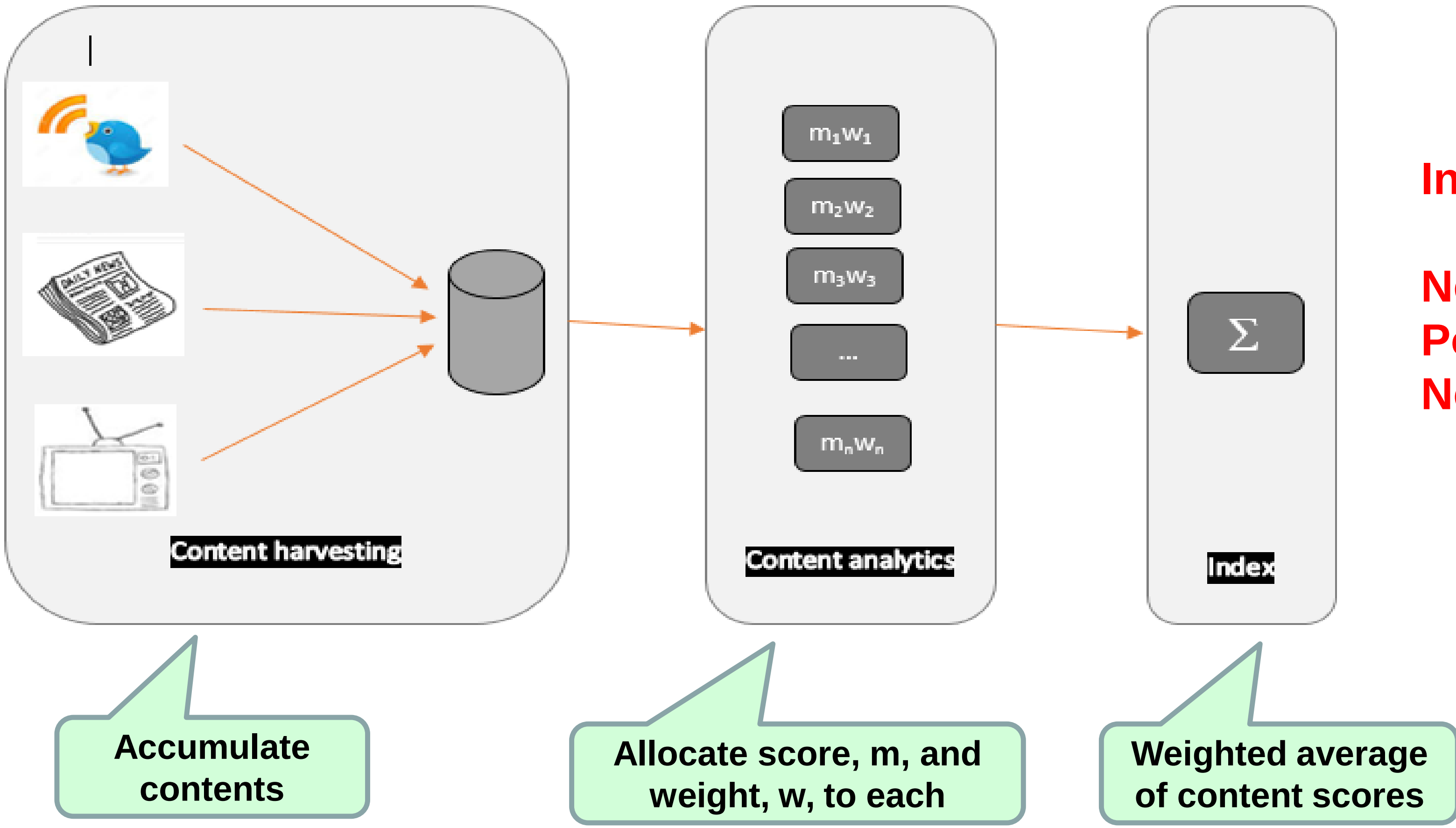
“Reputation Risk” - ***The difference between stakeholder expectation and organisation performance*** **(1)**

“Reputation Risk Measurement” - ***Numerical assessment of Reputation***

(1) Federal Reserve Boston (1995) Supervisory Letter SR 95-51 (SUP): Rating the Adequacy of Risk Management Processes

www.alva-group.com

Measurement



Index:

Neutral: 5.5
Positive: >5.5
Negative: <5.5

Measurement

Example content scoring

1. **On Twitter, @blognewcastle (203 followers) wrote: “*I'm a big fan of @santanderuk*** (11 Dec 2015)

Category	Sentiment	Score, s
Sentiment	Positive, qualified by ‘big’	8.0
Influence	Few followers: not influential	1.0
Prominence	Neutral	5.5
Relevance	No references to other organisations	10.0

Content Score = 24.5/4 = 6.125

Measurement

Example index compilation

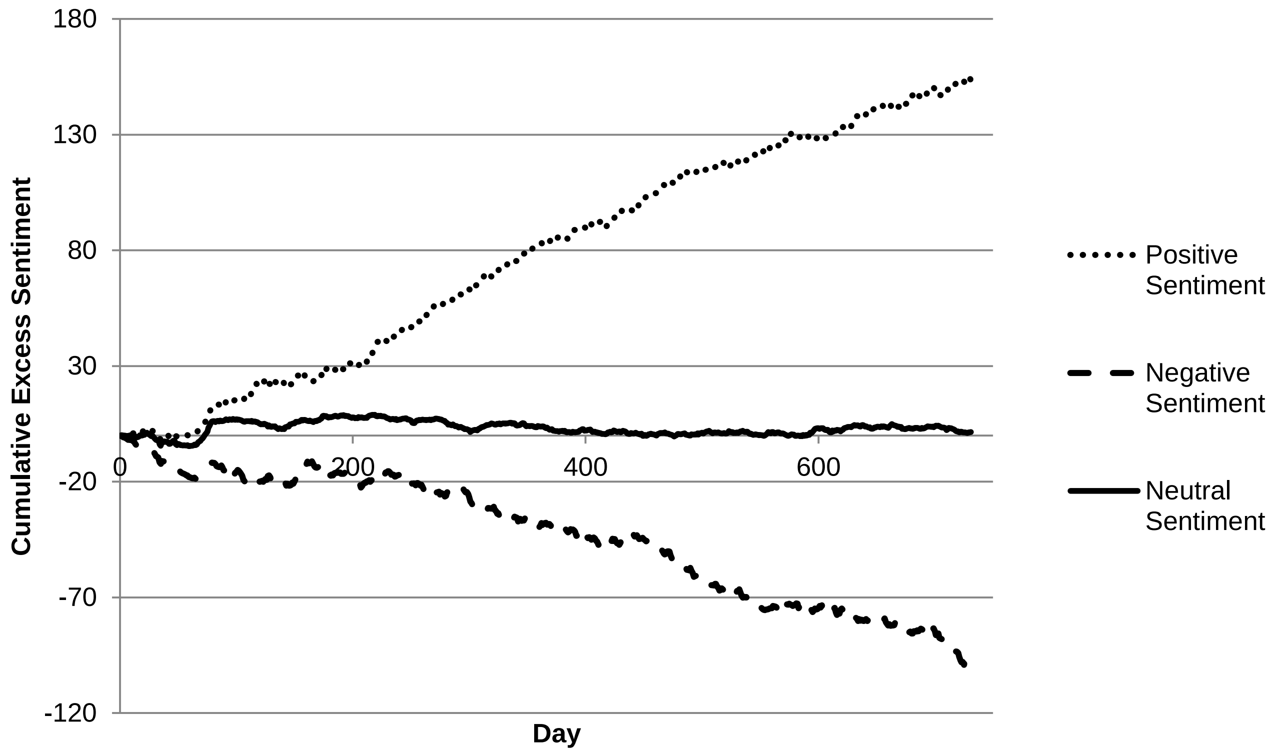
Content		Score, m	Weight, w	m×w
C1	“I'm a big fan of @XYZ-Bank”	6.125	0.12	0.735
C2	“XYZ-Bank does hardly provides good service” (Local TV consumer feature)	4.7	0.6	2.82
C3	“XYZ-Bank’s mortgage interest rates is the best available” (Sunday Times ‘Best Buy’ tables)	8.62	0.9	7.758
Sum			1.62	11.313

Weights reflect importance of content and source

Index value = 11.313/1.62 = 6.983

Measurement

Useful view: cumulative sentiment – used later to assess ‘network drag’



Measurement

Sentiment Analysis references

Comprehensive review and analysis: "Sentiment Analysis", Bing Liu 2015

Preliminary work: (e.g.) Wiebe 1990 and 1994, Hearst 1992

Early work: (e.g.) Wiebe (2000), Das and Chen (2001), Tong (2001),

Nasukawa & Lee (2003) – "Sentiment Analysis"

Dave et al (2003) – "Opinion Mining"

De Groot model for opinion formation [1]

- Described by a network of arbitrary complexity, with an influence matrix, *T*. In this case its structure is not known a priori
- T_{ij} is represents the weight that agent *i* places on the current belief of agent *j* in forming agent *i*'s opinion
- Agents start with an initial opinion $p(r=0)$, interact with other agents, and at the next time step ($r=1$), update their own opinion to $p(r=1)$ based on *T*. Further iterations produce $p(r=2)$, $p(r=3)$ [2, 3]…
- Assumption: full accessibility of information[4]

(1) DeGroot, M.H. (1974) Reaching a Consensus. *Jnl. American Statistical Association* (69). 118-121
(2) DeMarzo, P., Vayanos,D. and Zwiebel,J. (2003) Persuasion Bias, Social Influence and Unidimentional Opinions. Quarterly Journal of Economics (118) 909-968
(3) Golub, B. and Jackson. M.O. (2010) *Naıve Learning in Social Networks and the Wisdom of Crowds*. American Economic Journal Microeconomics. 112-149
(4) Pan, Z (2012) Opinions and Networks: How Do They Effect Each Other. *Comput Econ* 39,157–171

De Groot model for opinion formation

$\boldsymbol{p}(1) = \boldsymbol{Tp}(0)$

In general: $\boldsymbol{p}(r) = \boldsymbol{Tp}(r\text{-}1)$
which implies $\boldsymbol{p}(r) = \boldsymbol{T}^r\boldsymbol{p}(0)$, $r = 1,2,\ldots.$

There may be a limiting case that represents converged opinion [1]:

$$p(\infty) = \lim_{r\to\infty}\left(T^r p(0)\right)$$

(1) Chatterjee, S. and Seneta, E. (1977) Towards Consensus: Some Convergence Theorems on Repeated Averaging. J. Appl. Prob. 14, 89-97

De Groot model and sentiment

We have to discover a network based on agents' sentiment with respect to banks, and then derive the corresponding influence matrix T. In many other cases it's the other way round: the network is given and T is derived from it.

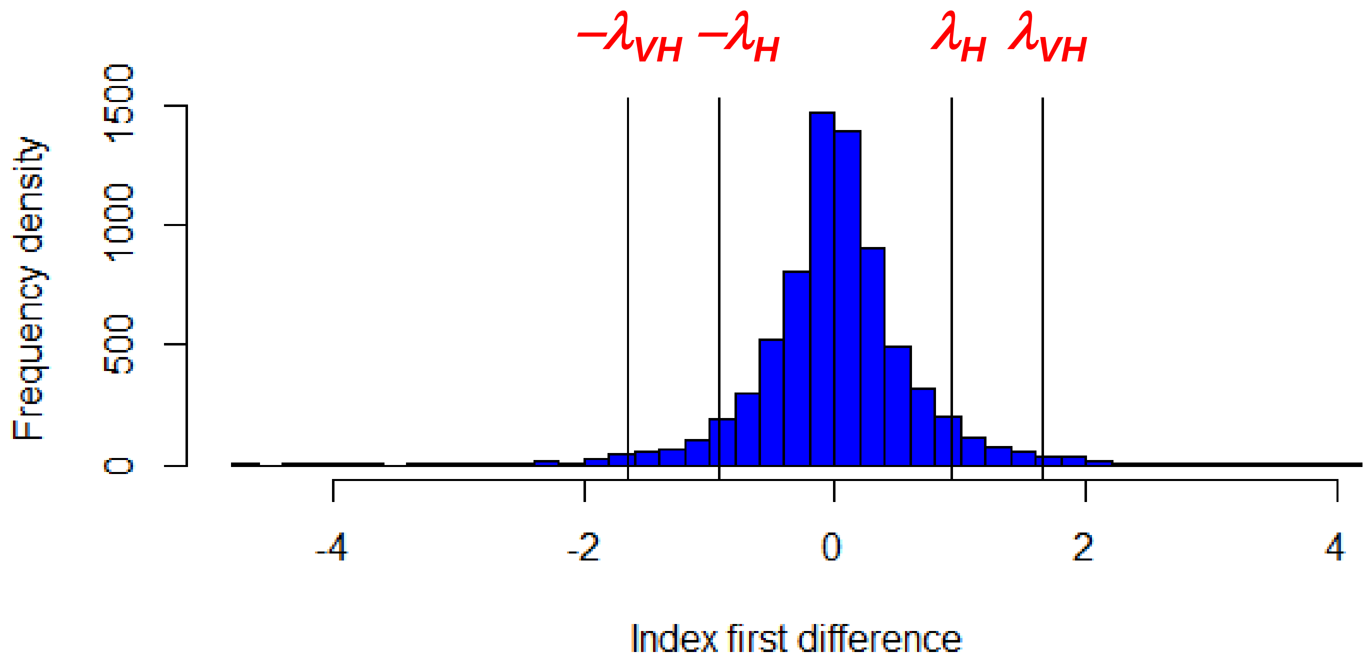
Let $S(i, t)$ be the sentiment of Agent i on day t. Then the sentiment movement is $M(i, t) = S(i, t) - S(i, t-1)$.

We count all movements greater than or equal to a 'high' threshold λ_H and all movements greater than or equal to a 'very high' threshold λ_{VH}.

$C(i, \lambda) = \{ M(i, t): abs(M(i, t)) \geq \lambda, 1 \leq t \leq n\}$, **where** $\lambda = \lambda_H$ or λ_{VH}

De Groot model and sentiment

Distribution of movements $M(i, t)$
λ_H marks the extreme 5% of movements
λ_{VH} marks the extreme 1% of movements



De Groot model and sentiment

Drive the influence matrix T using a Bayesian approach:

Given an Agent i, and a *different* Agent j, count the number of *very large* movements in the sentiment of Agent j ($i \neq j$), given that there was a *large* movement in the sentiment of Agent i.

$$T_{ij} = C(j, \lambda_{VH}) \mid C(i, \lambda_H)$$
$$= (C(j, \lambda_{VH}) \text{ and } C(i, \lambda_H)) / C(i, \lambda_H)$$

(a large movement in the sentiment of Agent i, associated with a very large movement in the sentiment of Agent j implies that Agent i has influenced Agent j)

De Groot model and sentiment

In the case $i = j$ there is a different interpretation.

it's a measure of the extent to which agent *i* values its own opinion, where 'agent' means all those who comment.

From the equation for T_{ij}

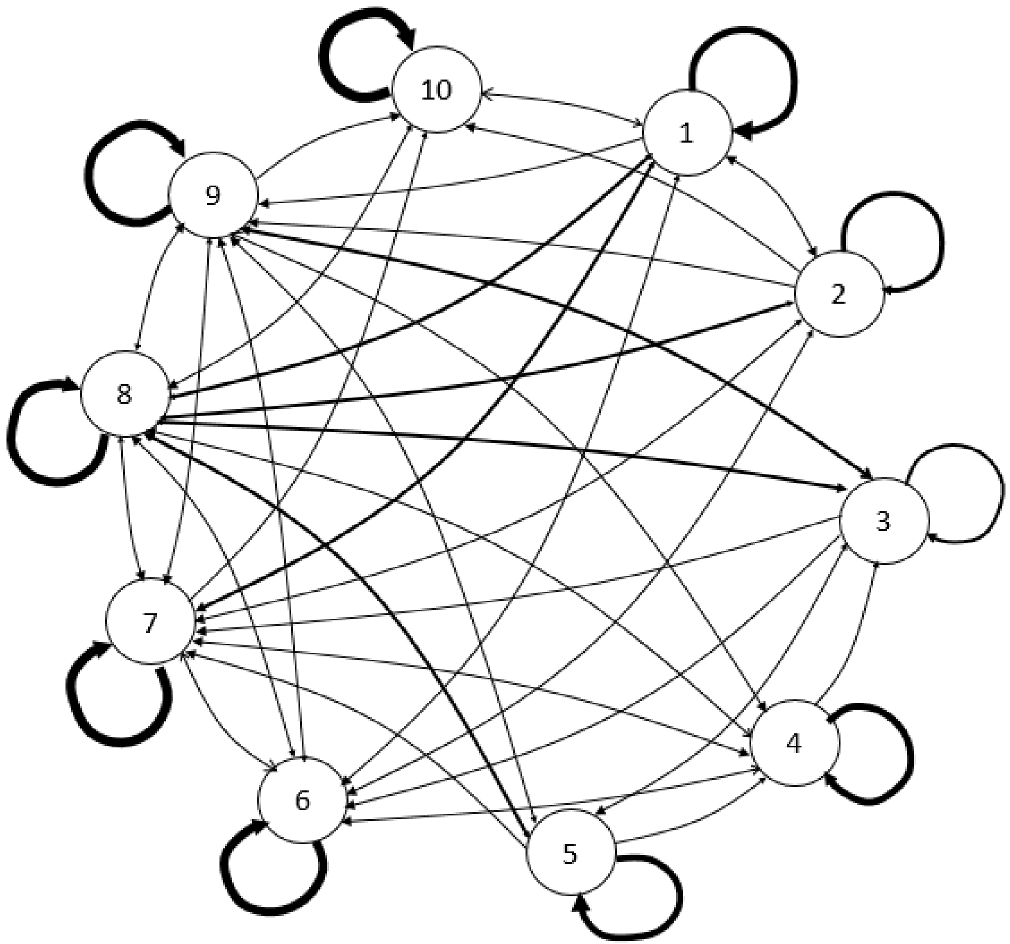
$C(j, \lambda_{VH}) = C(i, \lambda_H))$, so
$T_{ii} = C(i, T_{VH})/C(i, T_H)$.

Results

$$T = \begin{pmatrix} 0.459 & 0.084 & 0 & 0 & 0 & 0.079 & 0.115 & 0.189 & 0.074 & 0 \\ 0.088 & 0.237 & 0 & 0 & 0 & 0.131 & 0.177 & 0.192 & 0.062 & 0.113 \\ 0 & 0 & 0.238 & 0 & 0.133 & 0.122 & 0.133 & 0.179 & 0.194 & 0 \\ 0 & 0 & 0.109 & 0.437 & 0 & 0.160 & 0.140 & 0.154 & 0 & 0 \\ 0 & 0 & 0.103 & 0.099 & 0.375 & 0 & 0.146 & 0.181 & 0.096 & 0 \\ 0.052 & 0.049 & 0 & 0 & 0 & 0.479 & 0.204 & 0.142 & 0.073 & 0 \\ 0.058 & 0.078 & 0 & 0.038 & 0 & 0.086 & 0.518 & 0.084 & 0.097 & 0.041 \\ 0.049 & 0.095 & 0.050 & 0 & 0.033 & 0.078 & 0.120 & 0.483 & 0.060 & 0.033 \\ 0 & 0 & 0 & 0.064 & 0.109 & 0.162 & 0.084 & 0.117 & 0.465 & 0 \\ 0.103 & 0.095 & 0 & 0 & 0 & 0 & 0 & 0.146 & 0.100 & 0.556 \end{pmatrix}$$

Zero entries indicate that the corresponding network is not fully connected: not all agents can influence all others directly.

Results



Network corresponding to T

thin = non-influential
thick = influential

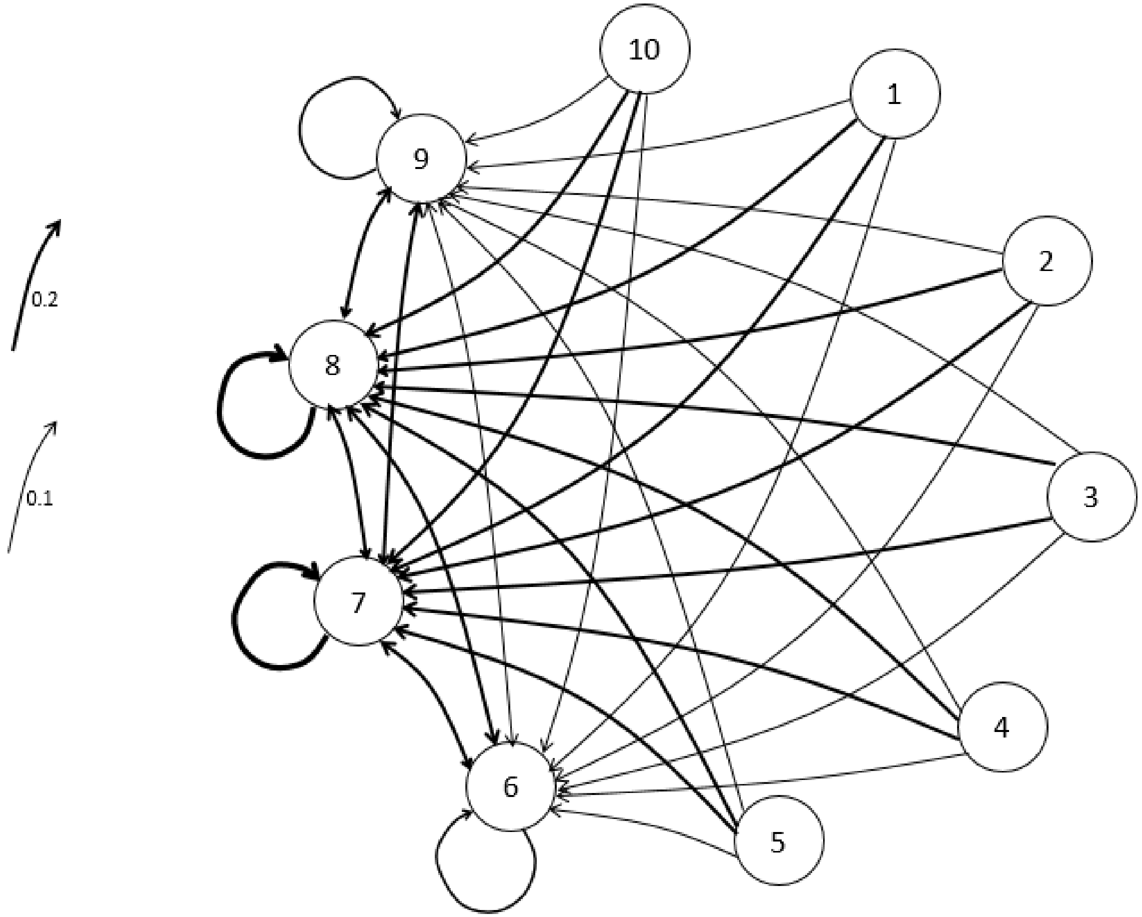
Not all edges are bidirectional

Results

$$\boldsymbol{T}_\infty = \begin{pmatrix} 0.078 & 0.072 & 0.024 & 0.036 & 0.038 & 0.152 & 0.212 & 0.207 & 0.127 & 0.053 \\ & & & & & \vdots & & & & \\ & & & & & & & & & \\ & & & & & \vdots & & & & \\ 0.078 & 0.072 & 0.024 & 0.036 & 0.038 & 0.152 & 0.212 & 0.207 & 0.127 & 0.053 \end{pmatrix}$$

In practice we observe convergence for T^t for $r > 6$
The network corresponding to T_∞ is fully connected

Results



Network corresponding to T_∞

Surprising results!

- **Agents 6, 7, 8 and 9 are most influential: they do not attract extreme negative comment.**
- **(Lloyds, NatWest, TSB, Virgin)**
- **'Bad banks' (2 – RBS, 5 – HSBC) are not influential.**
- **'Best bank' (3 – Nationwide) is not influential**

Results

Consensus view

The normalised cumulative excess reputation index values ($\sum(S(t)$-5.5)) gives an initial perception vector of sentiment with respect to banks:

$p(0)$ = (0.128, 0.027, 0.154, 0.180, 0.031, 0.135, 0.073, 0.117, 0.141, 0.085)

Then the consensus view is:

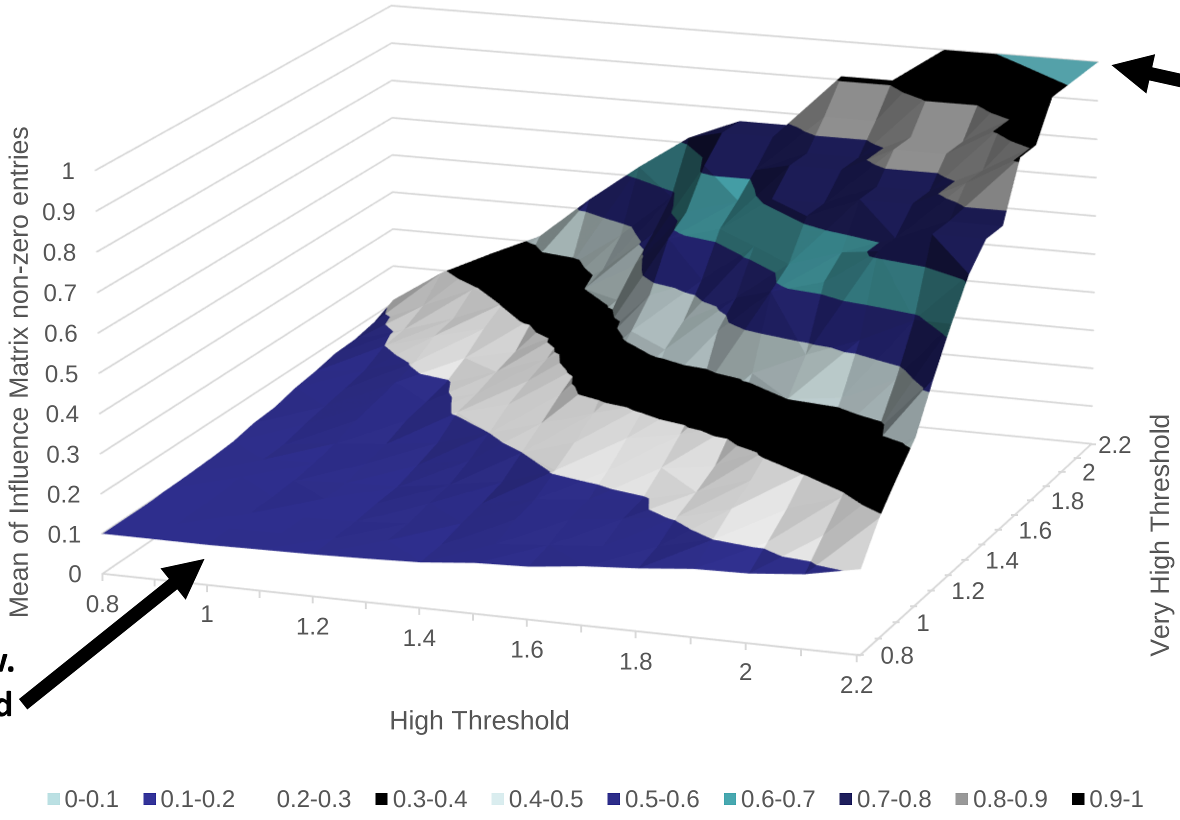
$p(\infty) = T_{\infty}\, p(0)$ = (0.104, 0.104, 0.104, …, 0.104)

This consensus value is an effective 'smoothing' of the initial perception vector. The value 0.104 corresponds to a cumulative excess 33.0: slightly positive. So as a group, banks are slightly good!

(There is an interesting view that $p(0)$ could be arbitrary or normally distributed from Pan (2010 and 2012))

Results

Variation of Bayesian Thresholds λ_H and λ_{VH} Generally insensitive



λ_H and λ_{VH} are set too high. Agents influence only themselves

λ_H and λ_{VH} are set too low. Agents are over-influenced by other agents.

Impact

Super-stressed effect of sentiment on product sales.

Product	Positive sentiment (%)	Negative sentiment (%)
Sales volume	3.4	7.9
Income	1.3	2.9
Profit after tax	1.3	3.6

Expected values of the effect of sentiment on product sales.

Product	Positive sentiment (%)	Negative sentiment (%)
Sales volume	1.6	2.3
Income	0.6	0.9
Profit after tax	0.7	0.9

Impact

The initial perception vector of sentiment with respect to banks:
$p(0)$ = (0.128, 0.027, 0.154, 0.180, 0.031, 0.135, 0.073, 0.117, 0.141, 0.085)
Was calculated from the cumulative excess vector C = ($\sum(S(t)$-5.5)):

C = (111.3, -212.3, 195.7, 47.4, -198.7, 133.2, -64.0, 76.3, 156.1, -27.9)

Let J be a vector whose entries are the column values of T_∞.
Define the total influence of the system, τ, by the scalar product
$\tau = C.J \sim$ 33.1

Each bank experiences an 'network drag' of value τ over 24 months, or τ /2 annually.
These are the % components of reputation attributable to the 'network'
(τ as a % of each member of C):

(14.9, -7.8, 8.4, 34.9, -8.3, 12.4, -25.8, 21.7, 10.6, -59.3)

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